

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Papaipema eryngii

Common Name:

Rattlesnake-Master Borer moth

Lead region:

Region 3 (Great Lakes-Big Rivers Region)

Information current as of:

06/01/2015

Status/Action

☐ Funding provided for a proposed rule. Assessment not updated.

☐ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

☐ New Candidate

☒ Continuing Candidate

☐ Candidate Removal

☐ Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status

☐ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species

☐ Range is no longer a U.S. territory

☐ Taxon mistakenly included in past notice of review

☐ Taxon does not meet the definition of "species"

☐ Taxon believed to be extinct

☐ Conservation efforts have removed or reduced threats

☐ More abundant than believed, diminished threats, or threats eliminated.

☐ Insufficient information exists on taxonomy, or biological vulnerability and threats, to support listing

Petition Information

☐ Non-Petitioned

☒ Petitioned - Date petition received: 06/25/2007

90-Day Positive:12/16/2009

12 Month Positive:08/14/2013

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

We find that the immediate issuance of a proposed rule and timely promulgation of a final rule for this species has been, for the preceding 12 months, and continues to be, precluded by higher priority listing actions (including candidate species with lower LPNs). During the past 12 months, the majority of our entire national listing budget has been consumed by work on various listing actions to comply with court orders and court-approved settlement agreements; meeting statutory deadlines for petition findings or listing determinations; emergency listing evaluations and determinations; and essential litigation-related administrative and program management tasks. We will continue to monitor the status of this species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures. For information on listing actions taken over the past 12 months, see the discussion of Progress on Revising the Lists, in the current CNOR which can be viewed on our Internet website (<http://endangered.fws.gov/>).

Historical States/Territories/Countries of Occurrence:

- **States/US Territories:** Arkansas, Illinois, Kentucky, North Carolina, Oklahoma
- **US Counties:** County information not available
- **Countries:** Country information not available

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories:** Arkansas, Illinois, Kansas, Kentucky, Missouri, North Carolina, Oklahoma
- **US Counties:** Jefferson, AR, Pulaski, AR, Cook, IL, Effingham, IL, Fayette, IL, Grundy, IL, Kankakee, IL, Livingston, IL, Marion, IL, Will, IL, Douglas, KS, Hardin, KY, Pender, NC, Osage, OK
- **Countries:** Country information not available

Land Ownership:

Current sites with rattlesnake-master borer moth populations are under both private and public ownership. Currently, the populations of rattlesnake-master borer moth are found on land owned by Illinois Department of Natural Resources (4 populations), Northeast Illinois University (1 population), The Nature Conservancy (1 population), Union Pacific Railroad (3 populations), the United States Army (Pine Bluff Arsenal - 1 population), the United States Air Force (Little Rock Air Force Base - 1 population), and other private (3 railroad sidings) and public ownerships (2 populations with undisclosed ownership).

Lead Region Contact:

ARD-ECOL SVCS, Laura Ragan, 612-713-5157, laura_ragan@fws.gov

Lead Field Office Contact:

ROCK ISLAND ESFO, Kristen Lundh, 309-793-5800, kristen_lundh@fws.gov

Biological Information

Species Description:

The adult rattlesnake-master borer moth measures 3.5–4.8 centimeters (cm) (1.4–1.9 inches) (Bird 1917, p. 125). It has a smooth head with simple antennae and a tufted body (Forbes 1954, p. 191, Bird 1917, p. 125). The forewing is rich purple brown to red brown becoming lighter and showing yellow powderings near the inner margin, a yellowish white dot at the base, and a powdery yellow patch at the apex (Bird 1917, p. 125). The middle of the forewing contains several distinct white and yellow spots (Bird 1917, p. 125). The hind wing is duller than the forewing and is described by

Bird (1917, p. 125) as smoky fawn overlaid with dark purplish powderings becoming darker at the margin. Male rattlesnake-master borer moths have distinctively identifiable genitalia, which allow distinction from other *Papaipema* moths of similar appearance (Forbes 1954, p. 193; Bird 1917, p. 126). Rattlesnake-master borer moth larvae develop in five instars, all of which have a yellowish head and are deep purplish brown with longitudinal white lines that are broken over the first four abdominal segments (Hessel 1954, p. 62; Bird 1917, p. 127).

Taxonomy:

The rattlesnake-master borer moth is a member of the family Noctuidae (owlet moths) and was first described in 1917 from individuals collected near Chicago, Illinois (Bird 1917, pp. 125–128). The genus *Papaipema* contains 53 species, all of which are found in North America and are root or stem boring (Schweitzer et al. 2011, p. 349; Panzer 1998, p. 48). Rattlesnake-master borer moth is the accepted common name for *Papaipema eryngii*.

Habitat/Life History:

Life History

Rattlesnake-master borer moths are univoltine (having a single flight per year) with adults emerging from mid-September to mid-October, and flying through mid- to late October or when the weather becomes too cold (Derkovitz 2013, pers. comm.; Hessel 1954, p. 59; Forbes 1954, p. 198; Bird 1917, p. 128). Their nocturnal habits make them hard to observe, thus adults feeding habits are unknown. Based on their short adult flight span, their underdeveloped mouth parts, and the large amount of stored fat, researchers postulate that they likely do not need much for nectar sources and likely use dew or oozing sap for imbibing moisture (Wiker 2013, pers. comm.). Adults will drink from sugar water when held in captivity (LaGesse 2013, pers. comm.). Based on their coloring, researchers believe the moths likely spend their days attached to plants or on the bottom of leaves, where their presence is camouflaged (Wiker 2013, pers. comm.).

In mid-October, females drop their eggs in the vicinity of the food plant, *Eryngium yuccifolium* (rattlesnake-master), where the eggs overwinter in the duff; young larvae emerge between mid-May and early June (Derkovitz 2013, pers. comm.; LaGesse et al. 2009, p. 4; Bird 1917, p. 126). Rattlesnake-master borer moths are monophagous (have only one food source), with larvae feeding exclusively on rattlesnake-master (Panzer 2003, p. 18; Hessel 1954, p. 59; Forbes 1954, p. 198; Bird 1917, p. 124). When larvae first emerge, they feed on the leaves of the host plant and the second instars burrow into the stem (or root) and on into the root where they remain until they pupate in mid- to late August (Derkovitz, pers. comm. 2013; LaGesse et al. 2009, p. 4; Bird 1917, p. 127). During the time that the larvae are actively boring into the host plant, researchers have detected cannibalistic behavior with some caterpillars moving into already occupied bore holes, killing the occupant and pushing them back out (LaGesse et al. 2009, p. 4). Rattlesnake-master borer moths diapause in the chamber they create in the host plant and pupation appears to take place either inside the chamber or in the soil and lasts 2–3 weeks (Derkovitz 2013, pers. comm.; LaGesse et al. 2009, p. 4; Bird 1917, p. 127). The boring activities of the rattlesnake-master borer moth generally result in the plant not producing a flower and can be fatal to the host plant (Wiker 2013, pers. comm.; LaGesse et al. 2009, p. 4).

Although there are no specific data on their home range, rattlesnake-master borer moths are not thought to disperse widely and have been described as “relatively sedentary” (LaGesse et al. 2009, p. 4; Panzer 2003, p. 18;). Panzer (2003, p. 19) found that female rattlesnake-master borer moths dispersed up to 120 meters (m) (394 feet (ft)) from where they were released and some traversed a 25-m (82-ft) gap that was devoid of host plants. LaGesse et al. (2009, p. 4) indicate that rattlesnake-master borer moths will disperse up to 2 miles (3-6 kilometers (km)) if the number of host plants is limiting.

Habitat

Rattlesnake-master borer moths are obligate residents of undisturbed prairie and woodland openings that contain their only food plant, rattlesnake-master (Schweitzer et al. 2011, p. 351; LaGesse et al. 2009, p. 4; Panzer 2002, p. 1298; Molano-Florez 2001, p. 1; Panzer et al. 1995, p. 115; Mohlenbrock 1986, p. 34; Hessel 1954, p. 59; Forbes 1954, p. 198; Bird 1917, p. 124). Although common in remnant prairies, rattlesnake-master occurs in low densities; it is a conservative species and has been found to have relative frequencies in restored and relict prairies of less than 1 percent (Danderson and Molano-Flores 2010, p. 235; Molano-Flores 2001, p. 1). The range of rattlesnake-master covers much of the eastern United States and spans from Minnesota south to Texas, east to Florida and back north to Connecticut (U.S. Department of Agriculture (USDA) Plants website 2013, <http://plants.usda.gov/java/>; Danderson and Molano-Flores 2010, p. 235). Although the plant has an expansive range, the loss of its tallgrass prairie habitat within that area is estimated to be between 82–99 percent (Samson and Knopf 1994, p. 418). Most high-quality prairies that remain are small and scattered across the landscape (Robertson et al. 1997, p. 63). In 1997, Robertson et al. (1997, p. 63) cited the Illinois Natural Areas Inventory, which found that of the 253 grade A and B (high-quality) prairies identified, 83 percent were smaller than 10 acres (4 hectares) and 30 percent were smaller than 1 acre (0.4 hectares). Most prairie destruction occurred between 1840 and 1900 (Robertson et al. 1997, p. 63).

Historical Range/Distribution:

All but one of the currently known rattlesnake-master borer moth sites have been identified since 1994. Little historical data exists for this species from before 1994.

Current Range Distribution:

Distribution and Status

All but one of the currently known rattlesnake-master borer moth sites have been identified since 1994. Little historical data exists for this species from before 1994. Some, but not all, of the sites have had some subsequent survey work to monitor individual populations.

Surveys for rattlesnake-master borer moths are conducted for both the adult and larval stage. Surveying for adult moths can be limiting, due to their sedentary nature, relatively short flight time, and the potential difficulties of surveying at night when the moths are active (LaGesse 2013, pers. comm.; Schweitzer et al. 2011, p. 19; LaGesse et al. 2009, p. 7; Metzler et al. 2005, p. 59). The usual survey method for *Papaipema* moths is with blacklight traps, although some researchers have found that rattlesnake-master borer moth may not be attracted to blacklights (LaGesse 2013,

pers. comm.; LaGesse et al. 2009, p. 4). It is difficult to determine population size based on capture of adults, due to their irregular attraction to blacklights and the difficulty of designing a study that would factor in how many adults may be flying at a given time and how far they may range (LaGesse 2013, pers. comm.; Schweitzer et al. 2011, p. 19; LaGesse et al. 2009, p. 7).

Larval surveys are conducted by searching the host plant for signs of boring (LaGesse et al. 2009, p. 7). Rattlesnake-master show signs of stress that indicate the occupancy of the root by rattlesnake-master borer larvae, which usually leave a pile of frass (excrement) below the bore hole (LaGesse 2013, pers. comm.; Hall 2012, pers. comm.). One benefit of larval surveys is that these surveys can be conducted for a longer time because evidence of larval infestation remains even after emergence (Schweitzer et al. 2011, p. 13). Researchers will often collect rattlesnake-master borer moth larvae and rear them to adulthood to confirm identification, as other similar species have been found in rattlesnake-master (such as the silphium borer moth (*Papaipema silphii*)) (Wiker 2013, pers. comm.). Much of the available census data for rattlesnake-master borer moths does not indicate the size or stability of the populations, but indicate only the continued presence or absence of the species in a specific area.

The rattlesnake-master borer moth is currently known to occur in five States: Illinois, Arkansas, Kentucky, North Carolina, and Oklahoma. Given that its food plant ranges across 26 States (USDA Plants website 2013, <http://plants.usda.gov/java/>), it is likely the rattlesnake-master borer moth's historical range was larger than at present; however, not much data supports its presence in other Midwest States. There are no historical records and no known records of rattlesnake-master borer moth in Indiana, although surveys have been conducted at several sites where the host plant occurs (Okajima 2012, pers. comm.). In Missouri, experts have examined numerous *Papaipema* specimens without finding any collections of rattlesnake-master borer moth (McKenzie 2012, pers. comm.). Experts indicate that, given the abundance of the host plant in Missouri, the species possibly occurs in Missouri and has not been detected (McKenzie 2012, pers. comm.). There are also no historical or known records for Iowa (Howell 2013, pers. comm.). Below we present specific occurrence information across the 5 States where the species is currently known to occur.

Population Estimates/Status:

Illinois

The State of Illinois has the most rattlesnake-master borer moth sites. At this time, 10 known sites contain rattlesnake-master borer moths in 8 Illinois counties (Will, Cook, Grundy, Livingston, Kankakee, Marion, Effingham, and Fayette). Nine of the known sites are thought to have extant populations and one is unknown. When Bird (1917, p. 124) first described the species, specimens were collected from the Chicago area, and five of the sites with extant populations are still found close to the city of Chicago (Will, Cook, Grundy, Livingston, and Kankakee Counties). There are two known sites in Will County—one of these sites is owned by the Illinois Department of Natural Resources (IDNR) and is extant, and the other is in railroad siding in private and State ownership and its population status is unknown. The population of rattlesnake-master borer moths within the IDNR site is thought to be stable (Derkovitz 2013, pers. comm.) Surveys of both adults and larvae have been conducted on this site, with the most recent larval survey in 2012 (Derkovitz 2013, pers.

comm.). This Will County site is protected and managed with prescribed burning to control woody species (Derkovitz 2013, pers. comm.). Although researchers have not found a decline of the moths within this site, poachers have removed individuals in the past and the location of the population is kept undisclosed for this reason (Derkovitz 2013, pers. comm.). Based on this information, we consider the status of the species to be extant on this site.

Larval surveys were conducted at the second Will County site (the railroad siding site), with presence last confirmed in 1997 (Illinois Natural Heritage Database 2012). This site was described by researchers as being very small and with few host plants when it was surveyed in 1997 (Derkovitz 2013, pers. comm.). The population of rattlesnake-master borer moths on this site is under private ownership of the railroad, however, it is contiguous with an Illinois State Nature Preserve (Derkovitz 2013, pers. comm.). During a larval survey in 2008, researchers found no signs of rattlesnake-master borer moths and suggested they may be extirpated from the site (Illinois Natural Heritage Database 2012). Based on this information, we consider the status of the species on this site to be unknown.

The presence of rattlesnake-master borer moths was confirmed on three other railroad siding prairies, one each in Livingston, Kankakee, and Grundy Counties (Illinois Natural Heritage Database 2012). The information on the Kankakee railroad siding is limited, although the species was confirmed on the site in 1997 (Illinois Natural Heritage Database 2012). Not much is known about the Livingston County site since the presence of the moth was detected here in 2001, as there have been no other known surveys of the site (Illinois Natural Heritage Database 2012). Larvae were first detected on the Grundy County railroad siding in 1997, and presence of the species at the site was most recently confirmed in 2012 (Derkovitz 2013, pers. comm.) Like the railroad siding prairie in Will County, these three sites are in private ownership and the unmanaged-populations are considered extant at these sites.

A second site owned by the Illinois DNR is located in Grundy County. The rattlesnake-master borer moth was first found in this site in 1990, with subsequent surveys in 1991, 1993, 1995, 1996, and 2003 (Illinois Natural Heritage Database 2012). Although an extensive survey of the population has not been done on this site, it is protected and managed, with the last prescribed burn occurring in 2011 (Derkovitz 2013, pers. comm.). Poaching of rattlesnake-master borer moths has occurred on this site, and so the location of the population is kept undisclosed (Illinois Natural Heritage Database 2012). The rattlesnake-master borer moth population on this Grundy County site is considered to be extant.

One other known population of rattlesnake-master borer moth close to Chicago occurs in Cook County, with rattlesnake-master borer moths introduced to the site in 1998 (Derkovitz 2013, pers. comm.; Illinois Natural Heritage Database 2012). This site is owned and managed by Northeastern Illinois University and larval surveys have been conducted each year since it was introduced to the site (Derkovitz 2013, pers. comm.). Area managers have found that the rattlesnake-master borer moths within this area are scattered into several small populations that have stayed approximately the same size since 1998 (Derkovitz 2013, pers. comm.). This site is considered to have an extant population.

In 2008, populations of rattlesnake-master borer moths were found for the first time in Marion and Effingham Counties in southern Illinois (LaGesse and Wiker 2008, pp. 7–8). The presence of the moth was confirmed at three sites through larval surveys; two sites within IDNR prairie areas in Marion County, and one within scenic right-of-way sections of a privately owned railroad siding that

spans through Marion and Effingham Counties (LaGesse and Wiker 2008, pp. 7–8). The railroad prairie is a large, linear prairie that covers approximately 64 hectares (158 acres) (Dietrich et al. 1996, p. 2). Of the two IDNR owned properties, one is a 65-hectare (160-acre) relict prairie area and the other is a 16 hectare (40-acre) prairie restoration, which contains the only known rattlesnake-master borer moth population that is not in a relict habitat area (LaGesse et al. 2009, p. 5). The number of bored rattlesnake-master plants was estimated to be between 200–250 on one IDNR site and the other contained between 250–300 bored plants (LaGesse and Wiker 2008, pp. 7–8). The railroad site contained between 5 and 10 bored plants (containing evidence of larval boring) and 15–20 bored plants (LaGesse and Wiker 2008, pp. 7–8).

In 2009, researchers returned to each of these sites to map and estimate the populations and establish monitoring protocols (LaGesse et al. 2009, p. 3). Survey methods included marking and outlining the perimeter of each rattlesnake-master subpopulation, flagging all plants that had signs of being bored by rattlesnake-master borer moths, and mapping the locations (LaGesse et al. 2009, p. 5). Individual plants that had evidence of rattlesnake-master borer moth damage were counted within each subpopulation, except for one subpopulation that was too large for such a count (LaGesse et al. 2009, p. 5). A sampling method was established to estimate the population within this large population of rattlesnake-master (LaGesse et al. 2009, p. 5). Researchers surveyed 67 subpopulations of rattlesnake-master across the 3 sites discovered in 2008 and found that 33 were inhabited by rattlesnake-master borer moths (LaGesse et al. 2009, p. 5). Although some populations were probably undetected, they estimated the overall population of rattlesnake-master borer moths to be approximately 4,600 (LaGesse et al. 2009, p. 6).

Management is conducted on all three of these sites in order to conserve and sustain the prairie communities. Prescribed fire is used on all of the sites, and the 65-hectare (160-acre) IDNR area also includes grazing to stimulate structural openings for prairie birds (LaGesse et al. 2009, p. 5). Researchers found that the grazing practices likely did not impact the rattlesnake-master borer moth population (see Factor A and E discussion in this finding). All three of the sites in southern Illinois are considered to contain extant populations.

In 2009, an application of herbicide affected populations of rattlesnake-master in the railroad siding prairie (LaGesse and Walk 2010, unpaginated). Consequently, in 2010 researchers surveyed the railroad prairie areas using the same techniques from 2009 in order to estimate and map the population of rattlesnake-master and rattlesnake-master borer moths and compare them to the findings from 2009 (LaGesse and Walk 2010, unpaginated). LaGesse and Walk (2010, unpaginated) found that 2 rattlesnake-master populations were completely destroyed and 19 declined between 2009 and 2010. Researchers found that both the overall population of rattlesnake-master and the density of the plants declined (LaGesse and Walk 2010, unpaginated). Fourteen populations of rattlesnake-master borer moths with a total of 112 caterpillars were detected in 2010 (LaGesse and Walk 2010, unpaginated). One-third of the nine populations of rattlesnake-master borer moths surveyed in 2009 declined; however, nine new populations were identified during the 2010 survey (LaGesse and Walk 2010, unpaginated). Due to an expanded survey area, researchers also identified an additional 24 populations of rattlesnake-master during the 2010 survey in Marion, Fayette, and Effingham Counties (LaGesse and Walk 2010, unpaginated). Within these new stands of rattlesnake-master, they found 7 new populations of rattlesnake-master borer moths with a total of 41 caterpillars. The five populations of rattlesnake-master borer moth identified within Fayette County in 2010 were the first recorded

occurrence of the moth for this county (LaGessee and Walk 2010, unpaginated). Although evidence of boring was found in rattlesnake-master in Fayette County in 2009, the areas were subsequently flooded due to heavy rain events (LaGessee and Walk 2010, unpaginated).

Kentucky

The rattlesnake-master borer moth is known from two sites in Kentucky, one each in Christian and Hardin Counties. The Christian County site is known from a single occurrence prior to 1999, but researchers have not found any sign of boring in rattlesnake-master in recent years (Laudermilk 2012, pers. comm.). The succession to woody plants has changed the composition of the plant community on site and experts believe that rattlesnake-master borer moth has been extirpated from the site (Laudermilk 2012, pers. comm.). The Hardin County site is thought to be extant based on larval counts dating back to 2003, with researchers finding between 100 and 500 feeding larvae during each survey year (Laudermilk 2012, pers. comm.). A comprehensive survey in 2008 indicated the largest number of feeding larvae found at that site was approximately 500. The site has a wide distribution of rattlesnake-master, although the moth has shown a clumped distribution (Laudermilk 2012, pers. comm.). This site is secure and its population considered extant, although its location is undisclosed due to concern of collection of the species.

Arkansas

The rattlesnake-master borer moth was first discovered on two sites in Arkansas in 1997, one each in Pulaski and Jefferson Counties (Weaver and Boos 1998, p. 8; Weaver and Boos 1997, p. 8). The Jefferson County site is located on the Pine Bluff Arsenal, where populations of the species were found in dry mesic savanna remnants (Zollner 2013, pers. comm.; Weaver and Boos 1998, p. 8). Researchers found the rattlesnake-master borer moths in small subpopulations of 3–12 individuals scattered throughout the patches of rattlesnake-master within the savanna remnants (Weaver and Boos 1998, p. 9). Surveys were also conducted within a railroad prairie on the Arsenal containing many rattlesnake-master plants, but the moth was not found there; it has not been found since the 1997 survey and researchers suggested that the fire regime in this area may be suppressing the colonization of this area by the moth (Zollner 2013, pers. comm.; Weaver and Boos 1998, pp. 16–17). Since the 1997 survey, one of the areas containing rattlesnake-master borer moths has been developed and an incinerator built on the area (Zollner 2013, pers. comm.). The other savanna remnants remain and have been surveyed for evidence of rattlesnake-master borer moth larva every year since it was discovered (Zollner 2013, pers. comm.). These annual surveys indicate that the population has stayed stable with generally the same number of larvae found, but always fewer than 20 individuals (Zollner 2013, pers. comm.). This area is managed yearly with rotational prescribed burning, usually before April 15 (Zollner 2013, pers. comm.). The Pine Bluff Arsenal site is considered extant.

The Pulaski County site is located within a mesic prairie area on the Little Rock Air Force Base (Weaver and Boos 1997, p. 8). The 1997 survey is the only survey conducted within this site (Popham 2013, pers. comm.; Zollner 2013, pers. comm.). Because of its proximity to the airfield and implementation of Bird Aircraft Strike Hazard rules, the prairie is mowed annually, which is the same management regime conducted onsite when rattlesnake-master was found in 1997 (Popham

2013, pers. comm.). Rattlesnake-master is known to occur in other areas of the Air Force Base; however, this prairie remnant is the only area where the moth has been detected (Popham 2013, pers. comm.) The status of the population and the prairie area on the Air Force Base is unknown.

Oklahoma

One known location of rattlesnake-master borer moth is in Oklahoma, in Osage County (LaGesse 2013, pers. comm.). During surveys conducted between 2000 and 2005, three populations were found within The Nature Conservancy's Tallgrass Nature Preserve, approximately 2–4 miles (3–6 km) apart (LaGesse 2013, pers. comm.). The first population to be studied on the Preserve had approximately 200 individuals. Later, the two other populations were found, both with approximately 50 individuals (LaGesse 2013, pers. comm.). The prairie community on the entire site is managed with grazing bison and a randomized prescribed fire regime designed to mimic the natural forces found on site prior to settlement (Hamilton 2013, pers. comm.). Although no surveys have been conducted on site since 2005, the management of the area is unchanged, so this site is considered extant.

North Carolina

Rattlesnake-master borer moth is known from a pine barrens, which is owned and managed by the State, in Pender County, North Carolina (Hall 2013, pers. comm.; Hall 2012, pers. comm.; Schweitzer et al. 2011, p. 351). The moth was first identified from a single adult on this site in 1994 (Hall 2012, pers. comm.; Schweitzer et al. 2011, p. 351). A prescribed burn was conducted on the site soon after the 1994 collection, and a subsequent survey resulted in location of one larva during the summer of 1995 (Hall 2012, pers. comm.; Schweitzer et al. 2011, p. 351). A 2002 survey of approximately 80–100 rattlesnake-master plants for larval feeding damage resulted in only one hole, indicating possible occupancy, however, no frass was found outside of the hole, which is a more reliable sign of larvae inhabitation (Hall 2012, pers. comm.). No surveys have occurred in the area since 2002 to verify the status of the population, so the status of the population on this site is considered unknown.

In summary, the rattlesnake-master borer moth currently occurs in five States: Illinois, Kentucky, Arkansas, Oklahoma, and North Carolina. Within these states, 16 sites have confirmed populations of the moth since 1993 (Table 1). Of these sites, 12 are considered to be extant, 3 unknown, and 1 is considered to be extirpated. Given the range of the food plant and the relatively recent discovery of all of the known populations, the range of the moth is possibly greater within these five States and within other States where rattlesnake-master is found.

Threats

A. The present or threatened destruction, modification, or curtailment of its habitat or range:

Rattlesnake-master borer moths are monophagous, feeding exclusively on the prairie plant,

rattlesnake-master (Schweitzer et al. 2011, p. 351; LaGesse et al. 2009, p. 4; Panzer 2002, p. 1298; Molano-Florez 2001, p. 1; Panzer et al. 1995, p. 115; Mohlenbrock 1986, p. 34; Hessel 1954, p. 59; Forbes 1954, p. 198; Bird 1917, p. 124). Although the overall range of rattlesnake-master is large (occurring in 26 States), the plant's relative densities in prairie are low, making up 1 percent of the prairie flora (Danderson and Molano-Flores 2010, p. 235; Molano-Flores 2001, p. 1). Rattlesnake-master is not known to occur in disturbed areas, and the extensive loss of undisturbed prairie in the United States has resulted in the remaining remnants that could support rattlesnake-master generally to be small and isolated. The rattlesnake-master borer moth's dependence on rattlesnake-master as its only larval food source makes the moth's potential habitat very narrow, which is likely limiting for this species. In their multiyear study, Panzer et al. (1995, p. 102) gauged the levels of remnant dependence (limited to natural area remnants) for 22 families and 6 genera of insects around the Chicago, Illinois, area and provided a list of remnant dependent species. They determined that rattlesnake-master borer moths are highly dependent on remnant patches of native prairie, not finding them in any disturbed areas (Panzer et al. 1995, p. 115). The disturbed area between the widely scattered remnant prairie patches that support the remaining rattlesnake-master borer moth populations will not support their food plant, rattlesnake-master, making these expansive areas uninhabitable to the moth. The conservation of good-quality prairie habitat is important for rattlesnake-master borer moth populations, especially those that are small and isolated, which would not be recolonized if they were extirpated. The loss of prairie habitat and the degradation and destruction of remnant habitat occurs in many ways, including but not limited to development, fire, flooding, invasive species encroachment, and succession, which are discussed in further detail below.

Conversion of Prairie for Agriculture

Since Euro-American settlement, conversion of prairie for agriculture is the most significant factor in the decline of American grasslands, and, thus, that of the rattlesnake-master borer moth. According to Samson and Knoff (1994, p. 419), by 1994, tallgrass prairie had declined 99.9 percent from historical levels in Illinois, Iowa, and Indiana and 99.5 percent in Missouri. Warner (1994) studied the transition of land use in Illinois since 1800. He found that between 1820 and 1920, Illinois went from almost two-thirds of the State covered with prairie to less than 1 percent (Warner 1994, p. 149). With the onset of intensive row-cropping after the 1950s, Illinois saw declines in diversified farming practices that included grazing of livestock on grasslands, leading to even further losses of grasslands (Warner 1994, p. 150). The loss of grasslands has been precipitous and has followed the settlement of the Midwest and the expansion and modernization of farming practices. The current threat of such conversion to extant populations is not well known and may now be secondary to other threats.

Nonagricultural Conversion of Prairie

The conversion of remaining prairie remnants for nonagricultural purposes continues to be a threat for some of the rattlesnake-master borer moth sites. Both Arkansas sites are within military installations and are under pressure of potential changes in land-use based on base priorities. An incinerator was constructed on top of one site containing rattlesnake-master borer moth within the Pine Bluff Arsenal (Zollner 2013, pers. comm.). Air Force officials are considering allowing development in one area of the Little Rock Air Force Base that contains populations of

rattlesnake-master (Popham 2013, pers. comm.). Although researchers did not find rattlesnake-master borer moths within this savanna area in 1997, removal of this area would decrease the opportunity of the moth to expand into other habitat.

In Illinois, several of the populations are close to Chicago and are within urban areas; however, all of those that are not railroad sidings are managed to maintain the prairie habitat and are currently protected from development. A high-speed rail project planned from Chicago, Illinois, to St. Louis, Missouri, may impact rattlesnake-master borer populations located within railroad sidings.

According to the U.S. Department of Transportation (USDOT) Environmental Impact Statement (EIS) (2012, pp. 5–34), all proposed alternatives would impact approximately 94 hectares (233 acres) of prairie remnants. The populations of rattlesnake-master borer moth occurring within the railroad sidings in Will, Livingston, and Grundy Counties are located along the same Union Pacific railroad track that has been identified in all of the build alternatives in the USDOT EIS (USDOT EIS 2012, Appendix A).

Although not all of the project plans have been finalized, potential construction impacts to the railroad siding prairies included in the EIS include construction of a second rail in order to provide double tracking for the entire alignment and construction of a parallel maintenance road along the alignment, both of which could impact populations of rattlesnake-master borer moth (USDOT EIS 2012, pp. 3–19). Surveys will be conducted in the coming years to identify all rattlesnake-master borer moth populations in these areas and potentially translocate individuals out of the construction zone (LaGessee 2013, pers. comm.). There are some indications that construction of the second track may impact the entire west side of the current alignment, effectively removing half of the prairie habitat in some places (LaGessee 2013, pers. comm.).

Fire

Rattlesnake-master borer moth populations existed historically in a vast ecosystem maintained in part by fire. Although prairie insects are adapted to fire in some ways, experts suggest that prescribed burns that are conducted frequently and cover entire insect populations can be detrimental (Schweitzer et al. 2011, p. 42). The rattlesnake-master borer moth is restricted in population size and distribution and thus is sensitive to management activities that are implemented across an entire site, such as fire (Panzer 2002, p. 1298). In his 2002 study, Panzer (2002, pp. 1296–1306) examined the recovery rate of fire-sensitive insects by assessing their post-fire response. Panzer (2002, p. 1306) identified four life history traits of duff-dwelling insects such as rattlesnake-master borer moth that were good predictors of a negative response to fire: (1) Remnant dependence (occurring as small, isolated populations); (2) upland inhabitation (dry uplands burn more thoroughly than wetter habitats); (3) nonvagility (low recolonization rate); and (4) univoltine (slower recovery rates for species with only one generation per year). He said that species exhibiting one or more traits should be considered fire-sensitive and species with all four traits should be considered “hypersensitive” to fire (Panzer 2002, p. 1306). The rattlesnake-master borer moth exhibits all four of these traits and thus, according to Panzer (2002, p. 1306), is hypersensitive to fire.

He indicated that univoltine, duff-inhabiting species like *Papaipema* moths should be considered especially susceptible to extirpation from fire (Panzer 2002, p. 1298). Adult rattlesnake-master borer moths are not known to disperse widely and are thought to be relatively sedentary making adults more vulnerable to fire (Panzer 2003, p. 18; LaGessee et. al 2009, p. 4). They lay their eggs

close to the host plant where they overwinter in the duff making the eggs and first instars susceptible to burns conducted from late fall to late spring before larvae have a chance to bore into the root of the plant (Derkovitz 2013, pers. comm.; LaGesse et al. 2009, p. 4; Bird 1917, p. 126). They are more resistant to the effect of fire during summer months after they have bored into the root and are below ground.

Rattlesnake-master borer moths were one of the species included in Panzer's (2003, p. 18) study of the importance of in situ survival, recolonization, and habitat gaps in the post-fire recovery of fire-sensitive prairie insects. Panzer studied the in situ survivorship of rattlesnake-master borer moths after burning 100 percent of the available habitat for some small populations that were at least 200 m (656 ft) from potential recolonization sources (2003, p. 18). Larval surveys were conducted to detect the presence of rattlesnake-master borer moths in order to eliminate the potential of detecting adults that may be recolonizing from other areas. Larvae were found in one out of two of the smallest populations burned that were between 4 m² and less than 8 m² (43 and 86 ft²) (Panzer 2003, p. 19). Panzer (2003, p. 19) found better survivorship on larger patches burned, with individuals surviving in all of the populations that were between 8 m² and less than 16 m² (86 and 172 ft²), and between 16 m² and less than 32 m² (172 and 344 ft²) (two out of two for each). A prescribed burn conducted in 1994 affected the entire population of rattlesnake-master borer moth at the North Carolina site (Hall 2012, pers. comm., Schweitzer et al. 2011, p. 351). The subsequent 1995 survey resulted in location of one larva, and the only other survey of the site (conducted in 2002) resulted in the detection of one potential bore hole (Hall 2012, pers. comm.). The presence of individual rattlesnake-master borer moths in areas that are completely burned indicates that in situ survival likely does contribute to the recovery of a population after a burn (Panzer 2003, p. 20); however, it is unknown if they can sustain themselves with repeated burns without recolonization.

The effects of fire on individual rattlesnake-master borer moth populations are difficult to ascertain as populations differ in size, density, and type of habitat they occupy. Also, some populations may be under stress from other threats making the effects of fire more detrimental (Panzer 1988, p. 87). The fire sensitivity of rattlesnake-master borer moth indicates that fire is a threat in habitats burned too frequently or too broadly. In order to reap the benefits of fire to habitat quality, rattlesnake-master borer moths must either survive in numbers sufficient to rebuild populations after the fire or recolonize the area from a nearby unburned area (Schweitzer et al. 2011, p. 251; Panzer 2003, p. 19; Panzer 1988, p. 88). In addition, the return interval of fires needs to be infrequent enough to allow for recovery of the populations between burns. Panzer indicates that burn programs that do not provide sanctuaries for fire-sensitive species, especially on small sites, will contribute to their loss across the landscape (Panzer 2003, p. 20). Prescribed burns that are designed to leave some patches of unburned habitat (by burning when it is wet or cool) may provide additional in situ survival, which may be important for fire-sensitive species on small sites (Panzer 2003, p. 20).

Complete fire suppression, however, can lead to the decline of prairie habitat, as well as savanna and pine barrens, as woody species become established (Schweitzer et al. 2011, p. 40; Panzer and Schwartz 2000, p. 363). The natural fire processes that once maintained prairie habitat have been altered by the modern landscape and without the addition of burning of these small patches of prairie habitat, they are subject to succession and the buildup of plant litter (Swengel 1998, p. 77). Although found commonly in undisturbed remnant prairies, rattlesnake-master is a highly

conservative species and has been found to have relative frequencies in restored and relict prairies of less than 1 percent (Danderson and Molano-Flores 2010, p. 235; Molano-Flores 2001, p. 1). Given its dependence on its host plant, proper fire management relative to the needs of its host plant and to retain prairie habitat is very important for rattlesnake-master borer moths. Of the 16 known rattlesnake-master borer moth sites, 10 are or have been managed with fire. The prairie community on the entire Tallgrass Prairie Preserve in Oklahoma is managed with a randomized prescribed fire regime that includes grazing designed to mimic the natural forces found on site prior to settlement (Hamilton 2013, pers. comm.). In Illinois, six sites are protected (four in State ownership, one owned by Northeastern Illinois University, and one private but managed as a natural area) and managed with prescribed fire, and all have extant populations that are considered stable. These sites are comparatively large and range from 1,700 acres (688 hectares) to the smallest at 40 acres (16 hectares), and all contain scattered populations of rattlesnake-master borer moths within the sites (Derkovitz 2013, pers. comm.; LaGesse 2013, pers. comm.). The savanna remnants within the Pine Bluff Arsenal in Arkansas where rattlesnake-master borer moth are found are also managed with fire (Zollner 2013, pers. comm.). This area is managed yearly with rotational prescribed burning usually before April 15 (Zollner 2013, pers. comm.). Annual surveys at the Pine Bluff Arsenal indicate that the population has stayed stable, with generally the same number of larvae found, but always fewer than 20 individuals (Zollner 2013, pers. comm.). The use of prescribed fire in the relatively large prairie remnants described above appears to be maintaining the prairie ecosystem at the sites without impacting the overall population of rattlesnake-master borer moths. The pine barrens site in North Carolina is comparably smaller and is all located within one burn unit (Hall 2013, pers. comm.). The entire area was burned in 1994, which may have impacted the rattlesnake-master borer moth population as only one larva was found during the subsequent survey in 1995, and evidence of only one borer hole was found in 2001 (Hall 2012, pers. comm.; Schweitzer et al. 2011, p. 351). Surveys were also conducted within a railroad prairie on the Pine Bluff Arsenal which contains many rattlesnake-master plants, but the moth has never been found there, either during the 1997 survey or subsequent surveys, and researchers suggested that the fire regime in this area may be suppressing the colonization of this area by the moth (Zollner 2013, pers. comm.; Weaver and Boos 1998, pp. 16–17).

At this time, it does not appear that fire prescriptions for any of the rattlesnake-master borer moth sites are designed to avoid burning while any of the life stages (adult, egg, larva) are located within the prairie duff layer or are designed so that only portions of the rattlesnake-master borer moth populations or its host plant are burned at one time. Research has shown that even when entire sites are burned, rattlesnake-master borer moths can survive in situ; however, given their sensitivity to fire it is likely that populations rely on recolonization from unburned sanctuaries. It is possible that not all of the populations on the larger sites are being burned at once, given that populations of rattlesnake-master borer moth are not found in single populations, but are scattered within the sites. Fire is a current and ongoing rangewide threat of high severity. Where burns occur, the moths need a sufficient amount of contiguous or nearby habitat from which immigrants can reinhabit burned areas.

Grazing

The productivity of prairie decreases as excess plant litter accumulates (Robertson et al. 1997, p.

57). Grazing and fire were two natural disturbance factors that historically maintained the prairie ecosystem by removing some of this biomass (Robertson et al. 1997, p. 56). Approximately 60 million plains bison (*Bison bison*) once grazed throughout the Midwest prairie (Samson and Knopf 1994, p. 419). Wallowing by bison and trampling by bison and cattle creates open areas that can increase species richness and heterogeneity in prairie (Robertson et al. 1997, p. 58). Grazing is used as a management tool in two of the rattlesnake-master borer moth sites; the Tallgrass Prairie Preserve in Oklahoma and an IDNR owned property in Illinois.

Both cattle and bison graze within the Tallgrass Prairie preserve, separated into two different units with different management regimes (Hamilton 2007, pp. 163–168). The 2,700 bison graze freely throughout the entire 23,500 acres (9,510 hectares) of the bison tract (Hamilton 2013, pers. comm.). The prescribed fire regime within the bison unit is randomized, and managers of the Preserve have found that bison generally graze in newly burned areas during the growing season in order to take advantage of the increased forage quality of the new regrowth (Hamilton 2007, p. 168). Researchers have found that, before the introduction of the bison, the rattlesnake-master on the Preserve was located in small populations (LaGesse 2013, pers. comm.) The rattlesnake-master has spread since the introduction of the bison, likely because the seeds of the plant have evolved small hooks that stick in the fur of the bison and are distributed as they range through the Preserve (LaGesse 2013, pers. comm.; LaGesse et al. 2009, p. 3).

The cattle unit is approximately 526 hectares (13,000 acres) and is managed with experimental treatments including “patch burn” treatments initiated under research by Oklahoma State University in 2001 (Hamilton 2007, p. 168). It is not known whether there are populations of rattlesnake-master borer moth or its host plant in the cattle unit of the Preserve. Cattle are used as grazing management on one of the Illinois DNR properties in order to create structure for grassland birds (LaGesse 2013, pers. comm.). Cattle are allowed into the property for approximately 60 days a year to “flash graze” the area (LaGesse 2013, pers. comm.). In their 2008 survey of this area, LaGesse and Wiker (2008, p. 8) found that cattle had consumed most of the flowering rattlesnake-master, but found no negative impacts to the rattlesnake-master borer moths. The researchers note that when cattle were introduced on a neighboring tract after the rattlesnake-master flowers had hardened, they were not eaten (LaGesse and Wiker 2008, p. 8). They suggest that introduction of cattle to a population of rattlesnake-master after the flowers have hardened may protect them from being grazed and avoid a decrease in seed production (LaGesse and Wiker 2008, p. 8). In both of these examples, bison and cattle herds are managed so that there is no overgrazing.

Lack of Management, Succession, Invasive Species

While inappropriate or excessive burning are threats to rattlesnake-master borer populations, the species is also under threat where there is no management to maintain prairie habitats. Without periodic disturbance, prairies are subject to expansion of woody plant species (secondary succession), litter accumulation, or invasion by nonnative plant species (e.g., smooth brome) (McCabe 1981, p. 191; Dana 1997, p. 5; Higgins et al. 2000, p. 21; Skadsen 2003, p. 52). Panzer and Schwartz (2000, p. 367) found a higher density of rattlesnake-master borer moths within fire-managed populations than fire-excluded populations in Illinois. Several sites with rattlesnake-master borer moths are not managed—invasive species and woody encroachment are threats to populations at those sites (Derkovitz 2013, pers. comm.; Laudermilk 2012, pers. comm.).

The railroad siding prairies in Will, Grundy, and Livingston Counties, Illinois, are all unmanaged and are under threat of invasion by woody plant species, like buckthorn (*Rhamnus* spp.) (Derkovitz 2013, pers. comm.). The succession to woody plants changed the composition of the plant community on one Kentucky site, resulting in the likely extirpation of rattlesnake-master borer moths (Laudermilk 2012, pers. comm.). Lack of management is considered to be a threat where the rattlesnake-master borer moth habitat is degraded or likely to become degraded due to secondary succession, invasive species, or both. This is likely the case at all six of the sites where there is not ongoing management of the prairie.

Flooding

Flooding is a threat to at least two rattlesnake-master borer moth populations. Although evidence of boring was found in rattlesnake-master in Fayette County, Illinois in 2009, the areas were subsequently flooded due to heavy rain events (LaGesse and Walk 2010, unpaginated). These populations were reconfirmed in 2010; however, researchers believe this area will likely continue to be affected by flooding in years of heavy rain (LaGesse 2013, pers. comm.; LaGesse and Walk 2010, unpaginated). The two Illinois DNR sites in Will and Grundy Counties have been documented with standing water in wet springs, which may affect the rattlesnake-master borer moth populations, depending on the duration and extent of the flooding (Derkovitz 2013, pers. comm.).

Herbicide Application

In 2009, an application of herbicide affected populations of rattlesnake-master in the railroad siding prairie in Marion, Effingham, and Fayette Counties (LaGesse and Walk 2010, unpaginated). LaGesse and Walk (2010, unpaginated) found that 2 rattlesnake-master populations were completely destroyed and 19 declined between 2009 and 2010. After comparing the data from 2009 and 2010, researchers found that both the overall population of rattlesnake-master and the density of the plants decline (LaGesse and Walk 2010, unpaginated). The impact to the food plant also affected the rattlesnake-master borer moths. Fourteen populations of rattlesnake-master borer moths with a total of 112 caterpillars were detected in 2010 with one-third of the 9 populations of rattlesnake-master borer moths surveyed declining from 2009 to 2010 (LaGesse and Walk 2010, unpaginated).

Conservation Efforts To Reduce Habitat Destruction, Modification, or Curtailment of Its Range

Seven of the 16 rattlesnake-master borer moth sites are currently owned and managed by State conservation agencies, a university, or management entity that protects them from development. All of these sites have some sort of management regime that is being implemented to maintain the prairie community that allows the subsistence of the species' food plant and protects the site from encroachment of woody habitat. Six of the seven sites are maintained with fire, and the seventh is maintained with fire and grazing. None of the management regimes are specifically designed to avoid direct impacts to the species, although the largest sites (five in Illinois and one in Oklahoma) have extant populations that appear to be stable.

Summary of Factor A

We have identified a number of threats to the habitat of the rattlesnake-master borer moth that

operated in the past, are impacting the species now, and will continue to impact the species in the future. The decline of the rattlesnake-master borer moth is the result of the long-lasting effects of habitat loss, fragmentation, degradation, and modification from agriculture, development, flooding, invasive species, and secondary succession. Although efforts have been made to effectively manage habitat in some areas, the long-term effects of large-scale and wide-ranging habitat modification, destruction, and curtailment will last into the future. Development of a high-speed rail project in Illinois will likely impact three known populations of rattlesnake-master in three counties, and development on the two military installations in Arkansas has destroyed one population of the species and may impact the other. Fire and grazing cause direct mortality of the moth or destroy food plants if the intensity, extent, or timing is not conducive to the species' biology. The application of herbicides affected several populations of rattlesnake-master and caused direct mortality to resident rattlesnake-master borer moths, causing a decline in some of the populations the following summer. Of the 16 sites considered to be occupied by the rattlesnake-master borer, all of the sites have at least one documented threat. Some sites have more than one threat, and concurrently acting threats may have more intense effects than any one threat acting independently. Almost all of the sites with extant populations of rattlesnake-master borer moth are isolated from one another, with populations in Kentucky, North Carolina, and Oklahoma occurring within a single site for each State, preventing recolonization from other populations. Of the sites that are currently protected from development and are under management to maintain the prairie ecosystem, all of them utilize management regimes (either burning or grazing or both) that could potentially impact individual rattlesnake-master borer moths and whole populations depending on the timing, extent, and frequency of the events. Two of these sites are also known to have standing water during large rain events in the spring which may impact rattlesnake-master borer moths.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

Illegal collection of rattlesnake-master borer moths has been noted at two IDNR managed sites in Illinois close to Chicago (Derkovitz 2012, pers. comm.; Illinois Natural Heritage Database 2012). The locations of these populations are not publicized. Although there have been no known poaching events within the Kentucky sites, managers are concerned and indicate that this species is sought after by lepidopterists in that State and keep the location of that site undisclosed (Laudermilk 2012, pers. comm.). Adult rattlesnake-master borer moths have been noted as hard to collect (see life history section); however, the host plant is easy to identify, which could make locating the larvae easier and the species more susceptible to collection (Schwietzer 2011, p. 45). Some extant populations of rattlesnake-master borer moths are known to be very small and made up of very few individuals. Because the host plant is easily identifiable, it is conceivable that an entire population could be impacted by one collector if enough host plants are removed. Collection from the remaining small and isolated populations could have deleterious effects on this species' reproductive and genetic viability. Due to the species' small population size, limited range, and the potential ease of collection of larval individuals, recreational collecting of this species presents a threat now and in the future throughout its range.

Conservation Efforts To Reduce Overutilization for Commercial, Recreational, Scientific, or

Educational Purposes

As discussed in Factor D: The Inadequacy of Existing Regulatory Mechanisms, the rattlesnake-master borer moths is listed as endangered on Illinois' State threatened and endangered species list, and Scientific Collectors Permits are required in order to collect the species throughout the State, providing protection for the populations within the 10 Illinois sites. However, two of these Illinois sites are known to have had illegal collections. Seven of the rattlesnake-master borer moth populations, in North Carolina, Illinois, and Oklahoma, are within protected areas, and permission is required to collect specimens within all of these sites. The species is not specifically protected through State laws in Kentucky, Arkansas, Oklahoma, or North Carolina, and we know of no proposals to add this requirement in the future, leaving the two sites in Kentucky, and the two sites in Arkansas unprotected.

C. Disease or predation:

There are no known diseases that are specific to rattlesnake-master borer moths, however, there is some evidence of parasitism in the moth, and known parasitism of the host plant, rattlesnake-master. While parasitism has been found by researchers in rattlesnake-master borer moth larvae, the species of parasite is unknown (LaGesse 2013, pers. comm.). Eggs and larvae of parasitic species have been found using rattlesnake-master borer moth caterpillars as hosts, although at this time there is no conclusive evidence of potential effects to the species or populations as a whole.

Second and third instar rattlesnake-master borer moths have also been known to cannibalize each other. During the time that the larvae are actively boring into the host plant, researchers have detected cannibalistic behavior with some caterpillars moving into already occupied bore holes, killing the occupant, and pushing them back out (LaGesse et al. 2009, p. 4).

The caterpillars of another species of moth, *Coetotechnites eryngiella*, are known to bore into the seeds of rattlesnake-master, sometimes affecting up to 60–70 percent of rattlesnake-master seeds (Danderson and Molano-Flores 2010, p. 235; LaGesse et al. 2009, p. 3; Molano-Flores 2001, p. 5). Danderson and Molano-Flores (2010, p. 242) found that the herbivory of rattlesnake-master by *C. eryngiella* causes a change in physical appearance of the inflorescence and resulted in a decrease in flower visitation by pollinators.

Summary of Factor C

Available information indicates disease is not a threat to the rattlesnake-master borer moth. There is evidence that parasitism and predation occur, however, the impacts to this species and its host plant rattlesnake-master are unclear. Researchers have found that the parasitism of rattlesnake-master by rattlesnake-master borer moths and *C. eryngiella* can affect individual plants and potentially whole populations. Some extant populations of rattlesnake-master borer moths are known to be very small, made up of very few individuals. It is possible that parasitism of the species by wasps and potentially the cannibalism by individuals competing for host plants may impact small populations of rattlesnake-master borer moths, especially those that are also under stress from other threats. Available information indicates that disease, parasitism, and predation are not threats that have substantial impacts to rattlesnake-master borer moth individuals or populations.

D. The inadequacy of existing regulatory mechanisms:

The rattlesnake-master borer moth is listed as endangered by two States in which it is found, Illinois and Kentucky. In Illinois, the moth is listed as endangered under the Illinois Endangered Species Protection Act, which “prohibits the possession, taking, transportation, sale, offer for sale, or disposal of any listed animal or products of listed animals without a permit issued by the Department of Conservation” (Illinois Endangered Species Protection Board 2011, p. 7). The Illinois Endangered Species Protection Board is responsible for determining which species are listed in the State and for advising the Illinois DNR on methods of protection and management of listed species (Illinois DNR website 2013, <http://www.dnr.illinois.gov/espb/Pages/default.aspx>). The Illinois DNR office of Realty and Environmental Planning administers the State’s threatened and endangered species consultation program and works with agencies, developers, and other project proponents to assess the potential effects of projects and potentially mitigate them (Illinois DNR website 2013, <http://www.dnr.illinois.gov/espb/Pages/default.aspx>). For development or agency projects that are determined to affect listed species, an incidental take permit is required (Illinois DNR website 2013, <http://www.dnr.illinois.gov/ESPB/Pages/EndangeredSpeciesPermitsandIncidentalTake.aspx>). Project proponents for the proposed High Speed Rail project from Chicago, Illinois, to St. Louis, Missouri, are currently working through the State’s consultation process, including requesting an incidental take permit for potential effects to rattlesnake-master borer moths in the alignment (LaGessee 2013, pers. comm.). For researchers, a collection permit is required for the possession of specimens or products of Illinois that are listed as threatened or endangered, and additional permits are required for collection of any species within the State’s parks, forests, and conservation areas, or Illinois Nature Preserves or registered Illinois Land and Water Reserves (IDNR website 2013, <http://www.dnr.illinois.gov/ESPB/Pages/EndangeredSpeciesPermitsandIncidentalTake.aspx>).

The rattlesnake-master borer moth is also listed as endangered in Kentucky by the State’s Nature Preserves Commission (Kentucky State Nature Preserves Commission 2013, p. 35). At this time Kentucky legislature has not enacted any statute that provides legal protection for species listed as threatened or endangered (Laudermilk 2013, pers. comm.).

The rattlesnake-master borer moth is not protected in Arkansas as it has not been named to the State list of threatened or endangered species and is not named in the State’s Wildlife Action Plan as a Species of Greatest Conservation Need (Arkansas Game and Fish Commission website 2013, <http://www.agfc.com/species/Pages/SpeciesEndangered.aspx>; Anderson 2006, p. 2028). It is also not protected under State threatened and endangered species statutes in Oklahoma and North Carolina (Oklahoma Department of Wildlife Conservation website 2013, <http://wildlifedepartment.com/wildlifemgmt/endangeredspecies.htm>; North Carolina Wildlife Resources Commission 2008, p. 8). However, the sites within these States are owned and managed by the State (in North Carolina) and The Nature Conservancy (in Oklahoma) and require a collection permit within these two sites (Hall 2013, pers. comm.; Hamilton 2013, pers. comm.). The U.S. Forest Service has designated the rattlesnake-master borer moth as a sensitive species in Region 9, which includes the State of Illinois (U.S. Forest Service 2003, p. 4). At this time there are no known populations of the species within the Forest Service’s lands, so the designation of sensitive species status for this species will have no benefit at this time. However, it may be

beneficial if populations are identified on Forest Service lands in the future.

To summarize, existing regulatory mechanisms, including State endangered species statutes, provide protection for 12 of the 16 sites containing rattlesnake-master borer moth populations. Illinois provides regulatory mechanisms to protect the species from potential impacts from actions such as development and collecting; however, illegal collections of the species have occurred at two sites. A permit is required for collection by site managers within the sites in North Carolina and Oklahoma, although no statutory mechanisms protect the populations in North Carolina, Kentucky, Arkansas, or Oklahoma, which leaves privately owned sites in Arkansas and Kentucky unprotected from collection.

E. Other natural or manmade factors affecting its continued existence:

Habitat Fragmentation and Population Isolation

Rattlesnake-master borer moths are habitat specialists, which has a strong negative effect on their distribution and abundance. The species is completely dependent on prairie habitat and, more specifically, on a single larval food plant species, rattlesnake-master. Habitat fragmentation has reduced the once extensive prairie habitat to a collection of isolated patches of varying quality. Most prairie remnants that remain have been or continue to be subjected to haying, grazing, dumping, fire suppression, or succession, all of which degrade prairie quality (Panzer 1988, p. 83). Prairie remnant-dependent species, such as rattlesnake-master borer moths, are more susceptible to extinction from stochastic events than other insects, due to their fluctuating population densities, poor dispersal abilities, and patchy distribution (Panzer 1988, p. 83). The potential for extirpation within patches is intensified by the addition of other threats such as development, fire, grazing, and succession. Rattlesnake-master borer moths are not known to disperse widely and have been described as “relatively sedentary” (Panzer 2003, p. 18; LaGesse et al. 2009, p. 4). Researchers believe that the species will remain within a habitat patch unless the amount of rattlesnake-master becomes limiting and the moths are forced to seek out additional food plants (LaGesse 2013, pers. comm.). The moths also have relatively short flight times of approximately 2 weeks and may only fly during the pheromone “calling” times of the female, which may be only a couple of hours a night (Wiker 2013, pers. comm.). Rattlesnake-master borer moths within the Tallgrass Prairie Preserve in Oklahoma may have recolonized to habitat that was 2 miles (3.2 km) from their original patch of rattlesnake-master when the food plant became scarce (LaGesse 2013, pers. comm.).

Recolonization like this is likely not possible for many of the remaining populations of the species as they are isolated from one another, most are surrounded by agricultural fields or urban areas with no connecting habitat, and most are separated by distances greater than 2 miles (3.2 km). Species that are widely distributed in small populations are more susceptible to catastrophic events, and extirpations at individual sites will be permanent if there are no populations close enough that can recolonize the area.

Railroad siding prairies may afford the species the most likely opportunity for migration between populations or into new patches of rattlesnake-master, as they contain the most contiguous habitat, sometimes spanning many miles. The large railroad prairie in Marion, Fayette, and Effingham Counties contains long stretches of connected habitat, with the entire prairie corridor stretching for 22 miles (35 km) (LaGesse et al. 2009, p. 6). Although populations of the food plant are described as patchy within the prairie habitat, this linear area affords the species the opportunity to disperse

without having to traverse urban or agricultural environments. The railroad siding prairies in Will, Grundy, and Livingston Counties occur along the same corridor, but the remnant prairie here is patchy and populations are described as being very small (Derkovitz 2013, pers. comm.; Illinois Natural Heritage Database, 2012). Although the railroad prairies may afford the species the most likely opportunity for migration between populations, these sites are not protected, are subject to development and other disturbance, and receive minimal or no management to maintain the prairie habitat. Also, small populations of rattlesnake-master borer moths may not be able to maintain large enough population sizes when they are under pressure from other threats to be able to produce enough adults to immigrate to new areas.

Even with proper prairie management, extreme weather patterns or severe weather events have the potential to significantly impact rattlesnake-master borer moth populations, because they can occur across a large geographic area. These events include extremely harsh winters, late hard frosts following a spring thaw, severe storms, flooding, fire, or cool damp conditions. Habitats isolated as a result of fragmentation will not be recolonized naturally after local extirpations, as described above, and extirpation of individual populations from catastrophic events is more likely when they are isolated and widely spread.

Isolated populations like those of the rattlesnake-master borer moth likely do not receive any immigration of individuals from other populations. Without sufficient gene flow, populations in small, fragmented habitats are unlikely to remain viable over the long term (Frankham et al. 2009, p. 309). There have been no genetic studies of the rattlesnake-master borer moth to date; however, populations within fragmented habitats, like the rattlesnake-master borer moth, are predicted to have lower genetic diversity than those that occur in contiguous habitat, due to restricted gene flow, genetic drift, and increased inbreeding (Frankham et al. 2009, pp. 334–335). Reduced fitness (reduced genetic diversity) results in a reduced ability to adapt to environmental change (Frankham et al. 2009, p. 523).

Twelve of the known sites containing rattlesnake-master borer moth are considered isolated, as they are not connected by contiguous habitat to other prairie containing rattlesnake-master and are not likely to be recolonized by the low dispersing adult rattlesnake-master borer moths. The Tallgrass Prairie Preserve in Oklahoma represents the largest area of contiguous prairie habitat in which the rattlesnake-master borer moth exists, but there are no other known populations in Oklahoma. Due to the few numbers and small size of remaining populations, and their degree of isolation, habitat fragmentation and isolation is a threat that has significant impacts to the rattlesnake-master borer moth across its range.

Climate Change

Our analyses under the Endangered Species Act include consideration of ongoing and projected changes in climate. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). “Climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be

positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

As is the case with all stressors that we assess, even if we conclude that a species is currently affected or is likely to be affected in a negative way by one or more climate-related impacts, it does not necessarily follow that the species meets the definition of an “endangered species” or a “threatened species” under the Act. If a species is listed as endangered or threatened, knowledge regarding the vulnerability of the species to, and known or anticipated impacts from, climate-associated changes in environmental conditions can be used to help devise appropriate strategies for its recovery.

Global climate change, with projections of increased variability in weather patterns and greater frequency of severe weather events, as well as warmer average temperatures, would affect remnant prairie habitats and may be a significant threat to prairie species such as the rattlesnake-master borer moth (Royer and Marrone 1992b, p. 12, 1992a, pp. 22–23, Swengel et al. 2011, p. 336, Landis et al. 2012, p. 140). Rattlesnake-master borer moth habitat may experience the effects of gradual shifts in plant communities and an increase in catastrophic events (such as severe storms, flooding, and fire) due to climate change, which is exacerbated by habitat fragmentation. The isolation of rattlesnake-master borer moth populations makes them unlikely to recover from local catastrophes without artificial reintroduction or propagation, because they are not close enough to other populations for recolonization to occur.

Documentation of climate-related changes that have already occurred throughout the range of the rattlesnake-master borer moth (e.g., Johnson et al. 2005, pp. 863–871) and predictions of changes in annual temperature and precipitation in the Midwest region of the United States (Galatowitsch et al. 2009, p. 2017), and throughout North America (IPCC 2007, p. 9) indicate that increased severity and frequency of droughts, floods, fires, and other climate-related changes will continue in the future. Recent studies have linked climate change to observed or predicted changes in distribution or population size of insects, particularly Lepidoptera (Wilson and Maclean 2011, p. 262). Climate change is an emerging threat and has the potential to have severe impacts on the species; however, at this time our knowledge of how these impacts may play out is limited. All of the sites within the range of the species are in an area that could experience the effects of climate change.

Prairie Management Techniques

Native prairie must be managed to prevent the indirect effects of invasive species and succession from affecting rattlesnake-master borer moth populations. If succession has progressed too far, established shrubs or trees must be removed in a way that avoids or minimizes damage to the native prairie. When succession is well advanced, managers must use intensive methods, including intensive fire management, to restore prairie plant communities. If not administered carefully prescriptive methods such as fire and grazing themselves can harm local populations of rattlesnake-master borer moths (for example, see Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range). Rattlesnake-master borer moths are susceptible to the effects of prairie management techniques much of the year because the eggs overwinter in the prairie duff, and early instars are located on the leaves and stems of the

food plant and do not bore beneath the surface of the soil into the root ball until late June (LaGesse et al. 2009, p. 4). The above life history traits and the adults' low dispersal ability make them susceptible to mortality from prescribed fires, except when they have bored into the root of the host plant. Eggs and first instar caterpillars are also more susceptible to the effects of grazing cattle and bison before they bore into the root of the rattlesnake-master below the soil surface.

If not appropriately managed with fire, grazing, or haying, rattlesnake-master borer moth habitat is degraded due to reduced diversity of native prairie plants and eventually succeeds to shrubby or forested habitats that are not suitable for rattlesnake-master. Rattlesnake-master borer moth has been extirpated from one site in Kentucky, likely due to the succession to woody plants, which changed the composition of the plant community on site making it no longer suitable for the moth (Laudermilk 2012, pers. comm.).

Indiscriminate use of insecticides and herbicides to control invasive species and agricultural pests is also a threat to the species. In 2009, an application of herbicide affected populations of rattlesnake-master in the railroad siding prairie in Marion, Effingham, and Fayette Counties (LaGesse and Walk 2010, unpaginated). LaGesse and Walk (2010, unpaginated) found that 2 rattlesnake-master populations were completely destroyed and 19 declined between 2009 and 2010. The decline in the food plant impacted the rattlesnake-master borer moths populations, as three declined from 2009 to 2010 (LaGesse and Walk 2010, unpaginated).

In summary, efforts to manage invasive species and woody encroachment, such as fire, grazing, and herbicide use, is a threat to the rattlesnake-master borer moth. These management techniques, if not administered with the species in mind, can cause direct mortality and may impact whole populations. At least one management technique is being used or has been used on 10 of the 16 sites with known populations of rattlesnake-master borer moths, and is occurring in all 5 States.

Conservation Efforts To Reduce Other Natural or Manmade Factors Affecting Its Continued Existence

The conservation activities discussed under Factor A Habitat Destruction, Modification, or Curtailment of Its Range may address some factors discussed under Factor E. Of the sites that are protected and managed (four Illinois DNR sites, one Northeast Illinois University site, the North Carolina site, and the Oklahoma Tallgrass Prairie Preserve site) all have some sort of management that is being implemented in order to maintain the prairie community in which the rattlesnake-master borer moth lives. However, those plans are not specifically designed to avoid direct impacts to the moth. We are unaware of any conservation efforts that would directly address the impacts from climate change to rattlesnake-master borer moths.

Summary of Factor E

Rattlesnake-master borer moths are significantly affected by habitat fragmentation and population isolation. Most of the remaining populations of the species are small and isolated, making them vulnerable to stochastic events and increasing the potential for extirpation from catastrophic events as natural recolonization from other populations is not possible. These small, isolated populations are likely to become unviable over time due to lower genetic diversity reducing their ability to adapt to environmental change (Frankham et al. 2009, pp. 309–335). Environmental effects resulting from

climatic change, including increased flooding and drought, are expected to become severe in the future and result in additional habitat losses. Although necessary for maintaining diverse prairie habitat and avoiding succession and invasive species, some prairie management techniques, such as fire and grazing, may cause mortality and impact rattlesnake-master borer moth populations if not administered carefully. Collectively, these threats have operated in the past, are impacting the species now, and will continue to impact the species in the future across its range.

Conservation Measures Planned or Implemented :

See Threats evaluation for individual threat-by-threat discussion of conservation actions that are planned or implemented.

Summary of Threats :

This status review identified threats to the rattlesnake-master borer moth attributable to Factors A, B, and E. The primary threat to the species is from habitat destruction and modification resulting in small, isolated populations that are subject to a greater risk of extirpation with little chance of recolonization (Factors A and E). The species has been found to be fire-sensitive and potentially affected by grazing activities, if they are conducted when life stages of the species are vulnerable, which is much of the year. Rattlesnake-master borer moths are dependent on one food plant, rattlesnake-master, which is a conservative prairie species and not generally found in disturbed habitats. Rattlesnake-master borer moths are currently not protected from collection or “take” in four of the five States in which it is found. Furthermore, poaching has been documented at two sites owned by the Illinois DNR, where it is listed as a State endangered species. Due to the historical habitat loss, current populations are small and isolated and thus are not resilient to ongoing threats.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

Conservation measures for rattlesnake-master borer moth include those that keep habitat for the species healthy and those that protect the species during prairie management actions. Although fire is an important tool used in managing rattlesnake-master borer moth habitat, the species has been found to be fire-sensitive when life-stages of the species are vulnerable. Prescribed fire in rattlesnake-master borer moth habitat should be planned to cause the least damage to the species by controlling the time and extent of prescribed fire. If possible, fire burning should be conducted when the species is the least vulnerable. This may be difficult for site managers since the species is the least vulnerable after larva have bored into the root of the host plant and before they emerge as adults (approximately mid-June to mid-September) and burning during this time may be harmful

to many other prairie plant, animal, and insect species. Therefore, burns should be planned so only some segments of prairies are burned at a time and not all of a populations is affected.

Prescribed burning or other prairie management is important to retain suitable habitat for the moth. Unmanaged habitat that is allowed to succumb to invasion of woody plants or non-native species may become unsuitable for the rattlesnake master borer moth.

Although the moth is protected from collection in some states, the exact locations of the populations should be protected if possible to protect it from collection.

Priority Table

Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/Population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/Population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/Population	9
	Non-Imminent	Monotype genus	10
		Species	11
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

Magnitude:

Some threats that the rattlesnake-master moth faces are high in magnitude, such as habitat conversion and fragmentation, and population isolation. These threats with the highest magnitude occur in many of the populations throughout the species' range, but although they are likely to affect each population at some time, they are not likely to affect all of the populations at any one time. Rattlesnake-master borer moths are habitat specialists, feeding solely on rattlesnake-master. Although rattlesnake-master is found in 26 States, the amount of tallgrass prairie in the United States has declined by approximately 82–99 percent (Samson and Knopf 1994, p. 418), and rattlesnake-master is generally not found in disturbed prairie. Much of the remaining potential habitat that has not been converted for agricultural purposes or developed in other ways is made

up of small remnant prairies that are widely scattered. These populations are isolated, making each one individually more likely to be extirpated if subjected to stochastic and catastrophic events. The small, isolated populations are also under threat of becoming unviable, as they receive limited or no immigration of individuals from other populations. Without sufficient gene flow, these populations will lose genetic diversity.

Other threats, such as agricultural and nonagricultural development, mortality from implementation of some prairie management tools, flooding, succession, and climate change are moderate to low threats because they affect only some populations throughout the range. The life history of rattlesnake-master borer moths makes them highly sensitive to fire. Although a useful tool in maintaining prairie habitat and fighting succession, prescribed burning has the potential to cause mortality of individuals through most of the year and can affect entire populations. Ten of the 16 sites with rattlesnake-master borer moths use fire as a management tool. Research has shown that even when entire sites are burned, rattlesnake-master borer moths can survive in situ. However, given their sensitivity to fire, populations likely rely on recolonization from unburned areas. It is possible that not all of the populations on the larger sites are being burned at once, because populations of rattlesnake-master borer moth are scattered within the sites. The population within the North Carolina site may have been impacted by this management tool as surveys conducted after the 1994 fire that affected the entire site showed evidence of only one individual larva (Hall 2012, pers. comm.). Conversely, complete fire suppression can also be a threat to rattlesnake-master borer moths as prairie habitat declines and woody or invasive species become established (Schweitzer et al. 2011, p. 40; Panzer and Schwartz 2000, p. 363). The rattlesnake-master is a conservative plant species and not found in disturbed prairies (Danderson and Molano-Flores 2010, p. 235; Molano-Flores 2001, p. 1). The population of rattlesnake-master borer moth on one Kentucky site is thought to have been extirpated due to succession of the prairie to woody species (Laudermilk 2012, pers. comm.)

Although conversion of prairie to agricultural purposes has been precipitous, we have no indication that it is currently a threat of high magnitude. Flooding and the application of herbicide are additional threats to the species, although their incidence has been localized and so are not considered of high magnitude. Climate change is an emerging threat, although it is not currently known to be affecting any of the populations of rattlesnake-master borer moths.

Regulatory mechanisms provide protection for 12 of the 16 known sites that contain rattlesnake-master borer moths. Seven of these sites are owned and managed by State agencies, nongovernmental organizations, and a university, and all rattlesnake-master borer moths in Illinois are protected from collection through the State's threatened and endangered species statute.

Although regulatory mechanisms are in place, several sites are currently under threat by development, and known illegal collections of the moth have occurred within two of the protected sites in Illinois. Although some threats to the rattlesnake master borer moth are high in magnitude, we consider most threats to the species to be of moderate to low magnitude.

Imminence :

Every known population of rattlesnake-master borer moth has at least one imminent threat, and some have several working in tandem. These actual, identifiable threats are covered in detail under the discussion of Factors A, B, and E of this finding and currently include conversion of habitat for

nonagricultural use, fire, flooding, succession, overutilization, and habitat fragmentation and population isolation. One Arkansas population of the species was impacted by construction of an incinerator on the Pine Bluff Arsenal, and three known populations in Illinois are under threat from the development of a high-speed rail project. Fire is used as a management tool on 10 of the known populations, is not prescribed in a way to avoid direct mortality to the species, and is thought to have adversely impacted the North Carolina population when it was burned entirely (Hall 2012, pers. comm.).

For those sites with no management, succession is an ongoing threat. For example, experts believe that specific rattlesnake-master borer moths populations have been extirpated due to the change in habitat from the succession to woody species (Laudermilk 2012, pers. comm.). Illegal collection is known from two Illinois DNR sites, and these two populations and one in Kentucky are kept undisclosed for fear of additional collection. Twelve of the known sites containing rattlesnake-master borer moth are considered isolated, as they are not connected by contiguous habitat to other prairie containing rattlesnake-master and are not likely to be recolonized by the poorly dispersing adult rattlesnake-master borer moths. Thus, the continuing effects of habitat fragmentation and isolation are a threat to the rattlesnake-master borer moth across its range. Although not all of the threats are found within each site that contains populations of rattlesnake-master borer moth, the collective threats are impacting all of the known sites, and we believe the impacts will continue to impact the remaining populations.

☐ Yes Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

☐ No Is Emergency Listing Warranted?

We reviewed the available information to determine if the existing and foreseeable threats render the species at risk of extinction now such that issuing an emergency regulation temporarily listing the species under section 4(b)(7) of the Act is warranted. We determined that issuing an emergency regulation temporarily listing the species is not warranted for this species at this time, because 5 of the 16 known populations have some sort of protections or management in place. However, if at any time we determine that issuing an emergency regulation temporarily listing the rattlesnake-master borer moth is warranted, we will initiate this action at that time.

Description of Monitoring:

All but one of the currently known rattlesnake-master borer moth sites have been identified since 1994. Little historical data exists for this species from before 1994. Some, but not all, of the sites have had some subsequent survey work to monitor individual populations. Four of the known populations were surveyed in 2012 with one of these sites monitored yearly. Survey information for other sites ranges from 2010 - 1997. Surveys are being planned in 2014 for Iowa and Missouri to possibly detect new populations.

Surveys for rattlesnake-master borer moths are conducted for both the adult and larval stage.

Surveying for adult moths can be limiting, due to their sedentary nature, relatively short flight time, and the potential difficulties of surveying at night when the moths are active (LaGesse 2013, pers. comm.; Schweitzer et al. 2011, p. 19; LaGesse et al. 2009, p. 7; Metzler et al. 2005, p. 59). The usual survey method for *Papaipema* moths is with blacklight traps, although some researchers have found that rattlesnake-master borer moth may not be attracted to blacklights (LaGesse 2013, pers. comm.; LaGesse et al. 2009, p. 4). It is difficult to determine population size based on capture of adults, due to their irregular attraction to blacklights and the difficulty of designing a study that would factor in how many adults may be flying at a given time and how far they may range (LaGesse 2013, pers. comm.; Schweitzer et al. 2011, p. 19; LaGesse et al. 2009, p. 7).

Larval surveys are conducted by searching the host plant for signs of boring (LaGesse et al. 2009, p. 7). Rattlesnake-master show signs of stress that indicate the occupancy of the root by rattlesnake-master borer larvae, which usually leave a pile of frass (excrement) below the bore hole (LaGesse 2013, pers. comm.; Hall 2012, pers. comm.). One benefit of larval surveys is that these surveys can be conducted for a longer time because evidence of larval infestation remains even after emergence (Schweitzer et al. 2011, p. 13). Researchers will often collect rattlesnake-master borer moth larvae and rear them to adulthood to confirm identification, as other similar species have been found in rattlesnake-master (such as the silphium borer moth (*Papaipema silphii*)) (Wiker 2013, pers. comm.). Much of the available census data for rattlesnake-master borer moths does not indicate the size or stability of the populations, but indicate only the continued presence or absence of the species in a specific area.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

Illinois, Kentucky, North Carolina

Indicate which State(s) did not provide any information or comment:

Arkansas, Oklahoma

State Coordination:

State agency staff in all states that contain the current populations of rattlesnake-master borer moth were contacted. We received specific population information from the Kentucky Natural Heritage Program; the Illinois Natural Heritage Program; and the North Carolina Natural Heritage Program. Other states replied that they had population records for the species or did not reply to requests. For states that have populations of the moth but where state agencies did not provide information, population-specific data was provided by other sources such as site managers (such as TNC) or researchers that had visited sites.

Literature Cited:

Literature Cited

Bird, H. 1917. New species and histories in *Papaipema* SM. (Lepidoptera.) No. 19. The Canadian Entomologist 49(4):121-128

Dana, R. 1997. Characterization of three Dakota skipper sites in Minnesota., Minnesota Department of Natural Resources, Natural Heritage and Nongame Research Program, St. Paul, MN.

Danderson, C. A. and B. Molano-Flores. 2010. Effects of herbivory and inflorescence size on insect visitation to *Eryngium yuccifolium* (Apiaceae) a prairie plant. The American Midland Naturalist 163(1):234-246

Deitrich, C., K. Methven, and D. Voegtlin. 1996. Inventory of select groups of arthropods of 12-Mile Prairie. Illinois Natural History Survey, Center for Biodiversity, Annual Report for the 1995-1996 fiscal year of the Multi-State Prairie Insect Inventory. Champaign, IL. 11 pp.

Forbes, W. T. M., 1954. Lepidoptera of New York and Neighboring States: Noctuidae, Part III. Volume 329 of Memoir. Cornell University. Agricultural Experiment Station, Ithaca, NY. 433 pp.

Frankham, R., J. D. Ballou, and D. A. Briscoe. 2009. Introduction to Conservation Genetics. Cambridge University Press, New York.

Galatowitsch, S., L. Frelich, and L. Phillips-Mao. 2009. Regional climate change adaptation strategies for biodiversity conservation in a mid-continental region of North America. Biological Conservation 142:2012-2022.

Hamilton, R. G. 2007. Restoring heterogeneity on the tallgrass prairie preserve: applying the fire-grazing interaction model. Pages 163-169 in R.E. Masters and K.E.M. Galley (eds.). Proceedings of the 23rd Tall Timbers Fire Ecology Conference: Fire in Grassland and Shrubland Ecosystems. Tall Timbers Research Station, Tallahassee, Florida

Hessel, S. A., 1954. A guide to collecting the plant-boring larvae of the genus *Papaipema* (Noctuidae). The Lepidopterists News 8(3-4):57-63

Higgins, J., G. E. Larson, and K. Higgins, F. 2000. Floristic Comparisons of Tallgrass Prairie Remnants Managed by Different Land Stewardships in Eastern South Dakota. Pages 21-31 in 17th North American Prairie Conference, North Iowa Area Community College, Mason City, Iowa.

Illinois Endangered Species Protection Board. 2011. Checklist of Endangered and Threatened Animals and Plants of Illinois. Illinois Endangered, Species Protection Board, Springfield, Illinois. 18 pp.

Illinois Natural Heritage Database, 2012, Nature Preserves, Land and Water Reserves, and Natural Heritage Landmarks in Illinois: Illinois Department of Natural Resources, Springfield, IL USA

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K., and A. Reisinger (eds.)]. IPCC, Geneva, Switzerland. 104 pp.

Johnson, W. C., B. V. Millett, T. Gilmanov, R. A. Voldseth, G. R. Guntenspergen, and D. E. Naugle. 2005. Vulnerability of Northern Prairie Wetlands to Climate Change. BioScience 55:863-872.

Kentucky State Nature Preserves Commission. 2013. Endangered, Threatened, and Special Concern Plants, Animals, and Natural Communities of Kentucky with Habitat Description. Kentucky State Nature Preserves Commission, Frankfort, KY. 50pp.

LaGesse, V. L., J. Walk. 2010. 2010 Rattlesnake master and rattlesnake master borer moth, Twelve-Mile Prairie; Effingham, Clay, Fayette, and Marion Counties, Illinois. survey report.

LaGesse, V. L., T. L. Esker, and J. W. Walk. 2009. 2009 Monitoring of *Papaipema eryngii*, the

rattlesnake master borer moth at Prairie Ridge State Natural Area and Twelve Mile Prairie. 23 pp.

LaGesse, V. L., J. R. Wiker. 2008. An insect survey of the upper Little Wabash River watershed. 14 pp.

Landis, D. A., A. K. Fiedler, C. A. Hamm, D. L. Cuthrell, E. H. Schools, D. R. Pearsall, M. E. Herbert, and P. J. Doran. 2012. Insect conservation in Michigan prairie fen: addressing the challenge of global change. *Journal of Insect Conservation* 16:131-142.

McCabe, T. L. 1981. The Dakota skipper, *Hesperia dacotae* (Skinner): Range and biology, with special reference to North Dakota. *Journal of the Lepidopterists' Society* 35:179-193.

Metzler, E. H, J. A. Shuey, L. A. Ferge, R. A. Henderson, and P. Z. Goldstein. 2005. Contributions to the Understanding of Tallgrass Prairie-dependent Butterflies and Moths (Lepidoptera) and their Biogeography in the United States. *Ohio Biological Survey Bulletin New Series*. Volume 15 Number 1. viii+143p.

Mohlenbrock, R. H. 1986. *Guide to the Vascular Flora of Illinois*. Southern Illinois University Press, Carbondale and Edwardsville, Illinois 507 pp.

Molano-Flores, B. 2001. Reproductive biology of *Eryngium yuccifolium* (Apiaceae), a prairie species. *Journal of the Torrey Botanical Society* 128(1):1-6

North Carolina Wildlife Resources Commission. 2008. *Protected Wildlife Species of North Carolina*. Raleigh, North Carolina 8 pp.

Panzer, R. J. 2003. Importance of in situ survival, recolonization, and habitat gaps in the postfire recovery of fire-sensitive prairie insect species. *Natural Areas Journal* 23(1):14-23.

Panzer, R. J. 2002. Compatibility of prescribed burning with the conservation of insects in small, isolated prairie reserves. *Conservation Biology* 16(5):1296-1307

Panzer, R. J. 1998. Insect conservation within the severely fragmented eastern tallgrass prairie landscape. (Master's Thesis). University of Illinois at Urbana-Champaign, Urbana, Illinois. 136 pp.

Panzer, R. J. 1988. Managing prairie remnants for insect conservation. *Natural Areas Journal* 8(2):83-90

Panzer, R. J., K. Gnaedinger, and G. Derkovitz. 2010. The prevalence and status of conservative prairie and sand savanna insects in the Chicago Wilderness Region. *Natural Areas Journal* 30(1):73-81

Panzer, R. J. and M. Schwartz. 2000. Effects of managing burning on prairie insect species richness within a system of small, highly fragmented reserves. *Biological Conservation* 96:363-369

Panzer, R. J., D. Stillwaugh, K. Gnaedinger, and G. Derkovitz. 1995. Prevalence of remnant dependence among the prairie- and savanna-inhabiting insects of the Chicago region. *Natural Areas Journal* 15(2):101-116

Robertson, K. R., R. C. Anderson, and M.W. Schwartz. 1997. The tallgrass prairie mosaic. Pages 55-87 in M.W. Schwartz, editor. *Conservation in Highly Fragmented Landscapes*. Chapman and Hall, New York, New York.

Royer, R. A. and G. M. Marrone. 1992a. Conservation status of the Dakota skipper (*Hesperia dacotae*) in North and South Dakota. U.S. Department of the Interior, Denver, CO.

Royer, R. A. and G. M. Marrone. 1992b. Conservation status of the poweshiek skipper (*Oarisma poweshiek*) in North and South Dakota. Page 31 Unpublished Report. U.S. Fish and Wildlife Service, Denver, CO.

Samson, F. and F. Knopf. 1994. Prairie conservation in North America. *BioScience* 44(6):418-421

Schweitzer, D. F., M. C. Minno, and D. L. Wagner. 2011. Rare, Declining, and Poorly Known

Butterflies and Moths (Lepidoptera) of Forests and Woodlands in the Eastern United States. U.S. Forest Service Technology Transfer Bulletin, FHTET-2011-1. 435 pp.

Skadsen, D. R. 2003. Dakota skipper population surveys for CCAA development in the State of South Dakota. Page 56. South Dakota Department of Game, Fish, and Parks, Pierre, SD.

Swengel, S., D. Schlicht, F. Olsen, and A. Swengel. 2011. Declines of prairie butterflies in the Midwestern USA. *Journal of Insect Conservation* 15:327-339.

Swengel, A. B. 1998. Effects of management on butterfly abundance in tallgrass prairie and pine barrens. *Biological Conservation* 83(1):77-89

U.S. Department of Transportation. 2012. Chicago to St. Louis High-Speed Rail Program Tier 1 Final Environmental Impact Statement, U.S. Department of Transportation Federal Railroad Commission, Washington DC.

U.S. Forest Service. 2003. Conservation Assessment for Eryngium Root Borer (*Papiapema eryngii*). U.S. Forest Service Eastern Region. Milwaukee, WI. 9pp

Warner, R. E. 1994. Agricultural land use and grassland habitat in Illinois: future shock for Midwestern birds? *Conservation Biology* 8(1):147-156

Weaver and Boos Consultants, Inc. 1998. A final report on insect surveys at the Pine Bluff Arsenal. Jefferson County, Arkansas. 21 pp.

Weaver and Boos Consultants, Inc. 1997. A final report on insects surveys at Little Rock Air Force Base. Pulaski County, Arkansas.

Wilson, R. J. and I. M. D. Maclean. 2011. Recent evidence for the climate change threat to Lepidoptera and other insects. *Journal of Insect Conservation* 15:259–268.

Personal Communication

Phone communication with G. Derkovitz, Restoration Specialist, The Nature Conservancy, Illinois (May 1, 2013)

Phone communication with G. Derkovitz, Restoration Specialist, The Nature Conservancy, Illinois (April 8, 2013)

Phone communication with S. Hall, Landscape Ecologist, Natural Heritage Program, North Carolina Department of Environment and Natural Resources (May 30, 2013).

Email communication with S. Hall, Landscape Ecologist, Natural Heritage Program, North Carolina Department of Environment and Natural Resources (October 17, 2012).

Phone communication with R. Hamilton, Director, Tallgrass Prairie Preserve, The Nature Conservancy, Oklahoma (April 17, 2013).

Email communication with D. Howell, Endangered Species Coordinator, Iowa Department of Natural Resources (April 15, 2013).

Phone communication with V. LaGesse, LaGesse & Associates Inc. Springfield, Illinois (April 15, 2013).

Phone communication with E. Laudermilk, Zoologist, Kentucky Natural Heritage Program (December 17, 2012).

Email Communication with P. McKenzie, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service (October 11, 2012).

Email Communication with J. Okajima, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service (August 30, 2012).

Email communication with J. Popham, Natural Resources Manager, United States Air Force, Little

Rock Air Force Base (May 23, 2013).

Phone communication with J. Popham, Natural Resources Manager, United States Air Force, Little Rock Air Force Base (April 25, 2013).

Email Communication with J. Wiker, Associate Research Scientist, Illinois State Museum (May 3, 2013).

Email Communication with J. Wiker, Associate Research Scientist, Illinois State Museum (May 2, 2013).

Phone communication with D. Zollner, The Nature Conservancy, Kentucky (April 17, 2013).

Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve:



07/08/2016

Date

Concur:



11/14/2016

Date

Did not concur:

Date

Director's Remarks: